Proceedings from a Workshop on

Right Whale Foraging in the Nearshore Waters of the Northern Gulf of Maine

April 15, 2005
Saco, Maine

Photo provided by New England Aquarium

Facilitated by the
Gulf of Maine Research Institute*

on behalf of the
Maine Department of Marine Resources+

Edited by Laura Taylor Singer* and Laura Ludwig+

Gulf of Maine Research Institute
Science. Education. Community.

MAINE DMR MARINE RESOURCES

Acknowledgments

This workshop, Right Whale Foraging in the Nearshore Waters of the Northern Gulf of Maine, was sponsored by Maine Department of Marine Resources and funded by National Whale Conservation Funds – a special project of NOAA Fisheries and the National Fish and Wildlife Foundation. Laura Ludwig of Maine DMR convened the panelists and coordinated the workshop logistics. Laura Taylor Singer of the Gulf of Maine Research Institute facilitated the meeting and produced the draft workshop proceedings and documentation with assistance from Traci Simpson and John Annala.

This workshop would not have been possible without the generous contribution of time and insight provided by the workshop participants. Each participant, whether a panelist or an observer, shared expertise and engaged in thoughtful dialogue regarding Right Whale foraging in the nearshore waters of the northern Gulf of Maine and potential for interaction with fixed gear.

Panelists (in alphabetical order):

Mark Baumgartner, Woods Hole Oceanographic Institution
Moriah Bessinger, Provincetown Center for Coastal Studies
Moe Brown, New England Aquarium
David Fields, Bigelow Laboratory for Ocean Sciences
Lew Incze, University of Southern Maine
Scott Kraus, New England Aquarium
Laura Ludwig, Maine Department of Marine Resources
Stormy Mayo, Provincetown Center for Coastal Studies
David Mountain, Northeast Fisheries Science Center
Jeffrey Runge, University of New Hampshire
Sean Todd, College of the Atlantic

Observers:

John Annala, Gulf of Maine Research Institute
Diane Borggaard, NOAA Fisheries/Northeast Regional Office
John Higgins, NOAA Fisheries/Northeast Regional Office
Tora Johnson, College of the Atlantic
Stephen Robbins III, Stonington, Maine Lobsterman/Take Reduction Team Alternate
Terry Stockwell, Maine Department of Marine Resources
Mason Weinrich, Whale Center of New England
Pat White, York, Maine Lobsterman/Take Reduction Team Member

Table of Contents

Executive Summary

The interaction of Right Whales and fixed fishing gear continues despite near-total compliance with the current ALWTRP regulations on the part of the Maine lobster industry. Vital to the survival of both Right Whales and the Maine lobster industry is more adaptive management which takes into account "best available data" relevant to Right Whales, their food source, and the presence of lobster fishing gear.

In addressing the problem of entanglement, it has been stated in previous workshop summaries (e.g. "Improving Right Whale Management and Conservation Through Ecological Research", Woods Hole ,4/16/04) that "resolution of this problem requires better information on how right whales forage...." There is consensus among scientists and managers that information regarding Right Whale foraging along the Maine coast is virtually non-existent. Foraging studies conducted in known Right Whale feeding areas (Cape Cod Bay, Bay of Fundy) provide serviceable data for Right Whale ecology studies, but not perhaps for local (i.e. State) management efforts.

Previous workshops have recommended development of better predictive modeling of Right Whale distribution. The Maine Department of Marine Resources (Maine DMR), in consultation with Northeast Fisheries Science Center staff and other scientists, determined that a workshop focus on the likelihood of Right Whale forage along the coastline of Maine would provide one model for predicting Right Whale distribution and could generate data that doesn't currently exist.

Oceanographers, plankton specialists and Right Whale biologists convened at the workshop and presented information pertaining to the processes that encourage zooplankton survival, aggregation and abundance; discussed the physical parameters of specific Gulf of Maine areas possibly conducive to zooplankton productivity; factored in known Right Whale distribution and migration trends; and provided recommendations for future study.

Workshop participants reached consensus about a series of research proposals that should be funded in order to gain better knowledge about Right Whale foraging in the nearshore waters of the northern Gulf of Maine. These proposals include long-term intensive aerial surveys for Right Whales along the Maine coast, opportunistic and focused forage sampling, assessment of bathymetric processes to determine likely areas of forage presence, and tagging Right Whales in Maine waters.

Summaries of each panelist's contributions are documented herein. Copies of the presentations given by panelists, as well as a list of previous work in the field of foraging study -- much of which was referenced by panelists in the Maine workshop -- are appended to this report.

Workshop Background and Desired Outcomes

Background:

The Workshop was convened by Maine DMR and met at the Saco Conference Center on April 15, 2005, in Saco, Maine.

Current federal regulations for mitigating fishing gear interactions with North Atlantic Right Whales (RW) are based on Right Whale ecology and foraging data procured primarily in nearshore and sandy habitats in the southern Gulf of Maine (south of 43 degrees). Previous workshops have identified the need to obtain better data on RW foraging ecology to more effectively inform management decisions (see Clapham, ed., 2004). Little is known about the foraging habits of RW on the rocky substrates and areas of strong tide along the coast of Maine. This workshop was held to identify information gaps and to develop a research agenda to identify areas of potential risk reduction for fishing gear interactions along the northern nearshore waters of the Gulf of Maine, and to assist the management process in development of alternative gear and fishing strategies in Maine based on best-available data.

Outcomes:

1) To document
   - What is known about foraging habits of RW in northern nearshore waters of the Gulf of Maine; and
   - What is known about the zooplankton used as a food source by RW in this area and how that is influenced by oceanographic conditions.

2) To develop a research agenda aimed at gathering data about if, how, when and where Right Whales and zooplankton interact within the northern nearshore waters of the Gulf of Maine.

Welcome and Introduction

Workshop Chair: *Laura Ludwig, Maine Department of Marine Resources*

This workshop is a result of Maine DMR's intent to secure data necessary to implement the State's Large Whale Conservation Plan – specifically, critical knowledge regarding North Atlantic Right Whale diving behavior, foraging ecology and habitat use along the Maine coast. During a foraging workshop convened in April 2004 by the Northeast Fisheries Science Center in Woods Hole (see Appendix), it was acknowledged that there is little known about the foraging habits of RW in the nearshore (coastal) waters of the northern Gulf of Maine, specifically Maine state waters.

While RW foraging habits and resource needs have been studied extensively in Cape Cod Bay (CCB), a different sampling scheme is needed for assessing the Maine coast. Although CCB is a different environment than the nearshore waters of the Gulf of Maine, research methods used there could possibly be modified for research in coastal Maine.

The correlation between RW distribution and foraging in the nearshore waters of the northern Gulf of Maine needs to be studied further in order to address critical management questions. More data is needed to determine better ways of managing the protection of RW and reducing the interaction of RW with fixed fishing gear.

The Maine foraging workshop was divided into three panel discussions, each led by a participant who framed the topic and reviewed information about what is known in the northern nearshore waters of the Gulf of Maine. Other panelists and observers added to the general discussion and clarified information. A chart-based discussion followed.

Right Whale Ecology and Foraging Panel

Panelists: *Scott Kraus, New England Aquarium (Lead); Moe Brown, New England Aquarium; Mark Baumgartner, Woods Hole Oceanographic Institution; Stormy Mayo, Provincetown Center for Coastal Studies; and Sean Todd, College of the Atlantic*

Scott Kraus, New England Aquarium

There have been no directed studies of RW feeding ecology in inshore Gulf of Maine (GoM). Although there is substantial information from Cape Cod Bay (CCB), this information is not relevant to feeding ecology in inshore GoM.

Right Whales are primarily concerned with two critical needs that drive their behavior – food and mating. Water temperatures are not a significant driving factor, though they are more concerned with hot water than cold water. Tagging surveys done in CCB and elsewhere show that RW dive from top to bottom, sampling the water column in search of food.

There hasn't been enough data collected to support RW habitat use patterns. Studies done in CCB may be applied to the nearshore areas of the GoM if the habitats are similar. Regardless of habitat, RW congregate for food.

The Maine DMR created a map for the workshop that provided sightings information for RW in the GoM. Although this information was "mildly informative", panelists were warned not to extrapolate on foraging predictions. There is no effort data to correlate with the sightings, so the information should not be used to infer distribution and movements.

Right Whales can travel long distances in a short amount of time and exhibit extensive movements – probably checking out traditional feeding grounds. For example, 100 miles is a relatively short distance for a RW to travel and RW can transit the entire GoM and then return to the same place in a short timeframe. There is no set "transit zone" that whales use (i.e. no established route) and travel pattern is random. There is no clear, definitive pattern of movement by age, sex, etc. Indeed, RW will visit many different places and can be found anywhere. The only observed trend in RW transit is that when inshore sightings of RW are made, those whales tend to be juveniles. Stormy Mayo commented that it is the juvenile RW which entangle most frequently.

Moe Brown, New England Aquarium

Even in areas where survey tracklines are surveyed with 100% coverage of the surface area, there are times when RW are not seen. Female Right Whales are remarkably absent from the sightings database the year after they stop lactating and while they are pregnant. The female's reproductive cycle is one year pregnant (year 1), one year lactating (year 2), and one year recovering (year 3), though they more typically give birth every five years. The females are seen significantly less often than other segments of the population (adult males, juveniles of both sexes) in the year before birth (year 1) and year after or recovery post-weaning (year 3). Many cows are most often sighted the year during lactation with a calf in tow.

A combination of whale sightings and buoy detection is used to monitor and study whale populations in CCB. Acoustic sensor buoys detect sounds of whales that are not seen in aerial surveys – no matter how intensive the survey, it's not foolproof to rely on aerial surveys alone.

Mark Baumgartner, Woods Hole Oceanographic Institution

Survey methods of the RW include aerial and shipboard sightings, acoustic sampling and satellite tagging. Each provides a different pattern of distribution. From 1999 to 2004, aerial surveys showed "very few" whales in Maine waters, but whales equipped with satellite tags in the late summer and early fall frequently visited Maine waters. There is a gap between documented RW research and RW natural behavior due to a non-systematic survey effort.

Aerial sightings are not ideal for spotting RW -- single animals can be difficult to spot from the air, particularly if they are diving deeply. Right Whales do spend time in SAGs (social active groups) that occur closer to the surface and are easier to spot. Whales move around a lot in

search of food and can move at speeds that would allow them to completely circumnavigate the GoM in just over two weeks.

Zooplankton sampling has shown that RW are not always spotted where *Calanus* is seemingly abundant. Traditional zooplankton sampling has shown that *Calanus* is abundant in the deep basins of the GoM, yet satellite-tagged whales seldom visited these basins. It may be more energetically beneficial for RW to dive shallow for feeding, rather than dive deeply in these deep basins; the "workable depth" is where the RW can feed efficiently. The deep basins of the GoM could be too deep for RW to dive and eat (though tagging in the Bay of Fundy has shown that feeding at 200m is no problem for them).

Satellite-tagging data indicates that it is unrealistic to look for zooplankton to find RW. In one study, tagged RW were found mostly in the margins of GoM -- on Jeffreys and SW Scotian Shelf -- while *Calanus* was found mostly in central GoM. Right Whales were outside of the zooplankton concentrations because there need to be certain physical processes to package the *Calanus* sufficiently for RW foraging.

Archival tagging data from the Bay of Fundy and the Scotian Shelf was presented from July/August during 2000 and 2001. Right Whales were tagged in the Bay of Fundy using a time-depth recorder (TDR) tag that detaches after 1-2 hours. Where the tagged whale resurfaced, CTD (conductivity/temperature/depth) and OPC (optical plankton counter) casts were immediately made. The OPC is designed to measure *Calanus* at the depth that the RW were observed to be doing systematic dives (> 100 m). The whales were diving into discrete thin layers of high density *Calanus* – 8-10x10^3 copepods/m^3 – layers as thin as 4 meters or possibly thinner. RW dove towards the bottom, stopped at a particular depth to feed for some time, then surfaced. The peak of *Calanus* abundance they were targeting existed just above the bottom mixed layer, which was 20-100m thick. Physical processes are likely organizing *Calanus* into thin layers -- the bottom layer of water was well mixed (temperature and salinity) and turbulent, and the *Calanus* was suspended above this. *Calanus* descend in late spring and early summer and go into resting stage at depths above bottom mixed layers – not feeding, but living off oil reserves – of peak interest to RW. Inter-annual variability may change where the *Calanus* settle.

During the TDR tagging study, some RW went into the bottom – one tag was left in the mud before popping to the surface, suggesting that dives are exploratory when there are insufficient concentrations of *Calanus.* Zooplankton patches are likely small and localized (a few hundreds of meters in dimension); presence of RW will indicate where to find zooplankton abundance and not vice versa (i.e., if you're around feeding RW you will find elevated abundance of *Calanus*). Highly concentrated zooplankton patches are difficult to find without a reference point of feeding whales. Sampling for *Calanus* outside of where a RW resurfaces shows that copepod counts are too low beyond where the RW are feeding – "we don't sample as well as Right Whales do." (S. Mayo)

Stormy Mayo, Provincetown Center for Coastal Studies

Right Whales are not interested in individual copepods, krill, etc. – they are interested in "patches." The physical processes which cause these patches are very important -- the Maine coast is apparently not conducive to patches forming. Patches in CCB are larger than in Bay of

Fundy – they are comprised of *Calanus* and other calanoids, some only 20cm thick with densities up to 26 million/m^3. In CCB there is not much feeding if the copepod density is less than 4000/m^3 but it depends on food – euphausiid density threshold can be lower. Residents of more than a day in CCB are presumed to be feeding.

This raises several questions: How do you deal with these small-scale structures? What can we say about the dense patches of food in the Gulf of Maine? – are patches deep, are they at the surface? Small-scale studies on coast of Maine may be the way to go. Can we manage distribution of RW in areas where they don't concentrate, for example in wider areas where RW move largely at random? If RW are moving all over the entire system, is the critical management question related to feeding? With regard to foraging there are three layers to look at: space, time & behavior. The critical components for RW foraging in CCB may not reflect elsewhere; important to look at energy, tide, temp, depth, seasonality.

Whale energy studies and calculations show that different densities of zooplankton influence feeding behavior. It takes more energy for a RW to feed open-mouthed, at the surface. More studies are needed in whale energetics, but there isn't an efficient way to study/test.

Sean Todd, College of the Atlantic

The College of the Atlantic/Allied Whale studies whales around Mount Desert Rock including the inner and outer Schoodic Ridges, with a focus on fin whales. That area is contained within Maine Lobster Management Zone B, and they have seen some seasonality in RW distribution and sightings in that zone, though bad fog in the last few years has restricted visibility. It is possible that the zooplankton are concentrating by bathymetric upwelling at Schoodic Ridge and the "Ballpark". Around Mount Desert Rock (MDR), there are two distinct feeding areas: 1) 4-6 nautical miles northeast of MDR where humpbacks and fin whales are sighted, and 2) southeast of MDR where RW are observed. Of the hundreds of historical RW sightings near MDR, only about 10% were skim feeding while the rest were diving (probably searching) and travelling. COA has extensive sightings data that could be transferred from logbooks to a database with some funding, for use by the DMR. Mason Weinrich offered that on Jeffreys Ledge in western Maine, there are two years of RW sightings data collected by the Whale Center of New England. During the first year, there was no surface feeding. However, during the second year the RW were exclusively surface feeding.

Framing the Important Biological and Physical Oceanography Questions

Panelists: *Lew Incze, University of Southern Maine (Lead) and David Mountain, Northeast Fisheries Science Center*

Lew Incze, University of Southern Maine

In the Gulf of Maine, RW have historically been thought of as foraging primarily on *Calanus finmarchicus*, although euphausiids, *Pseudocalanus spp*. and *Centropages spp*. copepods are also

sometimes abundant prey. Whales feed on and depend on very dense aggregations of prey, or patches, which occur in both the horizontal and vertical dimensions. The tendency of RWs to spend time in the southern Gulf of Maine (Great South Channel/northern Cape Cod Bay) in late spring/early summer (observed as feeding aggregations) and at the mouth of the Bay of Fundy (Grand Manan Basin) later in the season indicates that these are areas where such patches are more likely in a time/space sense (e.g., temporal and spatial frequency, patch sizes and duration). We assume that RW behavior is tuned to the environment, but these locations have also become subject study sites and therefore produce a probably biased view of whale foraging. Reportedly, the whales do not shoot from the southern GoM to the Bay of Fundy; they take their time transitioning between the two areas and likely forage in other spots along the way. The northern edge ("fingers") of Jeffreys Ledge is one such known area because of its relative proximity to shore and the consequent attraction of whale-watching vessels. Another area is the Schoodic Ridge/Mount Desert Rock region, which has been studied by personnel from the College of the Atlantic. How many other sites are frequented by Right Whales, where are these sites, and what do they offer for feeding? Answers to these questions are important for understanding human threats (primarily the distribution of fixed fishing gear) as well as the environmental factors that affect the general well-being of the RW population.

The prey aggregations reported by others as apparent thresholds for RW feeding depend on certain physical-biological interactions. These primarily are fairly small-scale occurrences that require the right physics but also adequate background concentrations of prey so that the coupling of prey abundance, behavior and local physics produces the needed patches and patch concentrations. The physics of these patches are of interest but difficult to study because they are small and ephemeral. The background concentrations are easier to sample but comprise only part of the puzzle. A hierarchical study plan is needed which would include modeling and sampling. The background also varies seasonally, interannually, spatially and over longer periods of time as a part of multi-year patterns of global-scale system change. Since *C. finmarchicus* is at the southern end of its range in the GoM, is the richest prey for RWs (due to size and lipid content), and is known to vary as a result of hemispheric forcing (NAO and Slope Water System), shifts between *Calanus* and other zooplankton and the results for RW are important for understanding trends in RW populations. A. Pershing and colleagues have suggested a model based on such background changes and this needs further testing. Mechanisms of patch formation are not necessarily the same in the northern and southern feeding areas and need to be investigated further and separately. Catching these patches in action has proven difficult and it may be that an examination of physical mechanisms would be a good strategy, under the assumption that the physical portion of the concentrating mechanism exists more commonly than patches, since the latter requires the favorable intersection of several variables. And the extensive shelf edge of the western Gulf has simply not been sampled very much. Since this is all part of the environment of RWs, an effort (exploratory at first) should be made to know these areas better. Based on what happens at Jeffreys, Schoodic Ridge, MDR and Grand Manan Basin, investigating the intersection of offshore banks with deeper water (80, 100, 120 m?) might be reasonably promising. As these are feeding areas for other top predators (cetaceans, large pelagic fish and birds), this is probably a "no regrets" strategy: we know little about these regions and the information will probably prove important for supporting ecosystem-based approaches to Gulf of Maine ocean area management.

With respect to the possible importance of deeper water intersecting with bottom topography (which might generate concentrating mechanisms), there are some deep gullies that extend into the coastline in such areas as the eastern Casco Bay, western Muscongus Bay, western Penobscot Bay and Frenchmans Bay. It is not presently known whether these areas are attractive to RWs, but this question also deserves further attention. The deep water and "steering topography" may stimulate exploratory interest on the part of whales whether or not the prey concentrations prove worthwhile. This in part is because the distances are short for a whale.

Finally, it should be pointed out that operational aspects of the Gulf of Maine Ocean Observing System (GoMOOS) make a broad-scale sampling and modeling effort reasonable. The last three years of circulation modeling reveals significant differences in the along-shelf transport in the coastal current system. It seems likely that this has consequences for zooplankton distributions and production, but we cannot say much beyond this general speculation without better data. The infrastructure is in place to support a better understanding of the system and its effects on RWs, and design conservation strategies accordingly. At the very least, for system changes beyond our immediate control, at least we will understand the causes of improving or declining status of the whale population and other components of the system. As pointed out above, it represents a no-regrets effort.

David Mountain, Northeast Fisheries Science Center

It is unclear what level of physics we have to deal with – macro-scale as we do now or thin layer micro-scale (scale of 1m, 20cm or thinner). Indeed, we need to deal with multiple scales to determine RW distribution and behavior. Fine scale oceanographic features need to be explored to determine zooplankton distribution. We need to be able to predict the likelihood of where and when these small-scale phenomena take place. In order to do this, environmental variables at fine scales need to be understood. The scale can be extremely small – the physical oceanography on a small scale affects the "patchability" of zooplankton. Physical oceanographers typically don't work on such small scales. Ideally we should move toward that effort.

NMFS historical zooplankton data is vertically integrated vs. knowing vertical distribution; also on coarse scale. Modeling exercises may be helpful in identifying areas that are likely locations for *Calanus* patches. Tracking environmental conditions that spawn zooplankton patches might be helpful.

John Annala also suggested looking at other fish species to locate *Calanus*. For example, Atlantic herring feed on *Calanus*. It might be easier to study herring and apply the knowledge of how they feed on *Calanus* to RW.

Zooplankton/*Calanus* Panel

Panelists: *Stormy Mayo (lead) and Moriah Bessinger, Provincetown Center for Coastal Studies; Jeffrey Runge, University of New Hampshire; and David Fields, Bigelow Laboratory for Ocean Sciences*

Stormy Mayo, Center for Coastal Studies

While all species of whales can get entangled, RW are more prone to entanglement and are less easily disentangled. The greatest entanglement threat occurs from the interaction between feeding RW aggregations and fixed gear (based on the number of entanglements involving the mouth). Concerns arise around deep-diving whales and ground lines. Therefore, RW feeding behavior is important for many management purposes. The orientation of the mouth may be important while RW are feeding. With regard to vertical lines in the water, RW do skim feed on their side.

Right Whale distribution in the GoM is largely controlled by zooplankton distribution. The RW diet is varied – they are mechanically non-selective, behaviorally selective -- and consists of all seven copepod species, salp (eurochordate), euphausiids, cyprids – all will release feeding behavior. Density threshold for Calanus feeding is lower than for other calanoid copepods.

It is critical to locate where the patches of zooplankton are and discourage gear placement in those areas, to avoid entanglements of whales in fixed gear. It is not likely that we can manage the distribution of RW, but it is important to be aware of the location of RW food sources. We should try to figure out the occurrence of fixed fishing gear in areas of high-density zooplankton. There should be a concentrated study around areas of high risk/whale entanglements.

Jeffrey Runge, University of New Hampshire

Calanus dominate the zooplankton assemblage in spring and early summer on Jeffreys Ledge, but other, smaller copepod species are more dominant inshore. The inshore Downeast region is not known to have a high abundance of *Calanus*. Copepods can migrate vertically and are transported horizontally by the currents. Starting in late spring and continuing into late fall or early winter the *Calanus* population goes into a lipid-rich dormant phase. During this dormant phase, there is a build-up of *Calanus* in a late pre-adult developmental stage in the GoM in the summer months. The highest integrated water column concentrations are found in the deep basins such as Wilkinson and Jordan Basins.

We still use vertical sampling methods to monitor water columns concentrations. UNH sampling includes vertical tows, bottom-to-top with a 200 micron net, on Jeffreys (Scantum) and GoMOOS buoy B three to four times a month. The sample composition on Jeffreys Ledge in spring and early summer is very high in *Calanus finmarchicus.* Different measurement tools are used to sample fine scale vertical distribution, including the Optical Plankton Counter, Video Plankton Recorder, electronically controlled multinet samplers (e.g. MOCNESS) and acoustics.

David Fields, Bigelow Laboratory for Ocean Sciences

Some algae augment zooplankton growth and others may inhibit growth. Thus even relatively large concentrations of phytoplankton may not produce large populations of copepods.

Copepods detect and respond to fluid motion. Vertical profiles suggest that different copepod species occupy different hydrodynamic regimes in the water column. Future research should

focus on the relationship between the local fluid conditions and where different species aggregate relative to these features. It may be fruitful to pare down our efforts and begin studying the behavior of animals at the scale of the individual.

Pat White questioned the relationship between algal blooms and zooplankton and suggested researching what feeds the copepods.

Mapping Discussion

Maine DMR provided a map that reflected ME DMR and NMFS Right Whale sightings databases, overlaid on to the Maine Lobster Management Zones with proposed Maine and NMFS gear modification exemption lines (see appendix). The Workshop participants discussed areas that appeared to be important for further research.

Nearshore Habitats:

S. Kraus remarked that the spatial distribution of fishing gear might be important information to map. Maine might be able to get a nearshore exemption if RW are not found in these areas. J. Runge suggested that *Calanus* are not typically found in great abundance in water shallower than 50m, except in places where they may be advected and concentrated by the circulation (such as Cape Cod Bay) and the inshore is not typical habitat. However, M. Baumgartner did not agree with that assessment. J. Runge remarked that bottom type has little to do with zooplankton distribution, but instead basin-scale advective transport as well as water depth are the first-order determinants of coarse-scale distribution. It was noted by S. Kraus that the coast of Maine has never been studied for RWs or their foraging resources in an intense fashion.

Oceanographic Approach:

D. Fields suggested that another approach would be to find an aggregation of plankton, then sample that area to find features that impact the resource. J. Runge noted that CCB and Scantum Basin are "ends of the line" where advecting zooplankton are regularly found. It's not bottom-type, but depth that's important to zooplankton. Find the RW and sample where they are found. An alternative suggested by S. Kraus was to do oceanographic sampling where the RW show up by looking at turbulence near rocky bottom (such as Mount Desert Rock and Jeffreys Ledge) and particulate sampling even if whales aren't there. M. Baumgartner remarked that data generated on Jeffreys Ledge would not translate to MDR, but data from a more rocky habitat (perhaps Schoodic Ridge) would be a better comparison.

S. Kraus recommended reviewing current and tide profiles that are available for the GoM and layer this information with depth. J. Runge suggested MDR and Jeffreys Ledge be explored further to find out where the prey are located to determine management and gear adjustments. It would be difficult to set up a rigorous sampling scheme along mid-coast Maine because there is not a long enough timeframe before federal rulings will be issued. One suggestion by D.

Mountain was to get focused looks at bottom stress to then extrapolate. Lots of work has been done on bottom boundary layers.

S. Kraus strongly encouraged Maine DMR to upgrade the Maine Sightings Points map created for the workshop so that it reflects effort and better represents RW distribution. He also suggested that permitted scientists place time and depth recorders (TDR) on as many whales as possible to gain critically needed information.

M. Baumgartner recommended initiating an intensive aerial survey effort inside three nautical miles (i.e. State waters) during every possible weather window to find the aggregations of RW and then sample for plankton. It was suggested by S. Mayo that a mix of sampling schemes be used.

When asked about the timeframe to address current management questions regarding RW entanglements, D. Borggaard noted that 2008 is when the current proposed regulations will go into effect with the possibility of an amendment after that. Therefore, 2006 and 2007 are the only seasons to conduct work. However, there are current on-going studies that could be augmented to allow for pilot work in 2005. S. Todd mentioned that the College of the Atlantic could add to current sampling plans for this summer. Other possibilities include work on Jeffreys Ledge with Whale Center of New England and Woods Hole; and work in CCB.

Sampling Method:

Sampling "opportunistically" (by authorized persons) with CTD and TDR methods where the whales are known to be present such as Jeffreys Ledge and MDR was discussed. Instrumentation could be ready to go when the RW show up in these locations. Sampling with a CTD on a daily basis and opportunistically when RW aggregate was also suggested.

S. Mayo suggested that the bottom layer is the focus (*pseudocalanus*) of current management discussions about ground lines. The workshop participants discussed how to sample at depth. One idea was to translate CCB bottom layer data with CTD existing data. L. Incze recommended a nearshore plankton-sampling program. Collect more than you need then figure out what you want to analyze. J. Runge described areas that might be likely locations for plankton, so-called "ends of the line", where the bathymetry advects zooplankton aggregations. Hydroacoustic sampling was suggested be ruled out as the bottom would interfere with the signal at depth.

P. White raised concerns about the cost of an aerial survey and suggested using existing platforms such as lobster boats, whale watch charters and ferries. A discussion followed and it was determined that both an aerial survey with industry participation would be the most promising strategy, providing the industry participants were fully engaged.

Research Agenda

Workshop participants agreed with earlier findings that there is a large gap in information about RW in the nearshore area of the GoM (i.e. in State waters, out to 3 nm from shore). This is particularly relevant as this area is predominantly rocky and tidal habitat and is the area most populated with lobster gear. Approximately 80% of Maine's lobster fishing effort is within the three-mile limit of State waters. Regulations regarding float rope height that are based on other habitat types may not be applicable or effective in this area.

Are there zooplankton layers near the bottom, on hard bottom and high current habitats, and do RW feed in these areas? There currently isn't enough data to answer the question of *Calanus* gathering at the bottom of the coastal ocean. Is there a layer at the bottom that the RW would dive for? How can we study the rocky bottom of the nearshore GoM, as has been done in the Bay of Fundy and CCB? It is hard to sample the bottom habitat, as sampling gear often is lost.

There needs to be flexibility in take reduction programs that allows fishermen to fish both the nearshore/inshore areas and the muddy to rocky bottom.

The workshop participants suggested the following areas of research to begin addressing these critical management questions for Maine:

Sightings Map:

The map used for the Workshop discussion was based on opportunistically recorded sightings information only. The map should be improved by including sightings information per unit effort (SPUE). In addition, information about the density and location of lobster traps may be useful to managers. This information is currently being compiled by Maine DMR.

Aerial Surveys and Lobster Vessel Observations:

There has been no targeted aerial survey to collect sighting information in the nearshore area of the GoM. Obtaining this information was seen as the top priority in order to determine if and where RW occur, as well as which areas are of greatest management concern for RW.

- The aerial survey should be conducted for a year (minimum) and take place approximately every other week. It was estimated that the entire Maine coast could be covered in 2-3 days.
- A network of active, trained lobstermen should be recruited to participate in a RW observer program that includes a daily log of whales observed. The number and location of participants should allow for adequate special coverage of the area. This information would be used to corroborate the aerial survey data and provide the lobster industry with a means of contributing to the database on RW.

Site-specific Studies:

Two areas in Maine were identified that currently experience regular visitations by RW and also encompass rocky habitats. There are already active research projects in these areas and this work should be augmented to increase the type of information being sought.

Mount Desert Rock –

- Bathymetry of the area should be mapped.
- A regular schedule of CTD casts should be made to correlate RW visits with environmental parameters.
- TDR tags should be available to allow for opportunistic tagging by authorized researchers.
- Pump sampling should be considered.

Jeffreys Ledge –

There is much sampling work already happening here, though it should be focused on when and where the RW are present.

Physical Oceanographic Modeling:

It has been observed (in CCB and elsewhere) that RW focus their feeding behavior in areas with dense patches of *Calanus* and other zooplankton. These patches may be at the surface or at depth, but zooplankton may aggregate in specific "dead-end" areas. It may be possible to label certain areas as less likely to be RW feeding areas due to physical oceanography including bottom stress, turbulence and presence of the mixed layer. Current NMFS data should be explored and modeled to see if these "dead-end" areas can be identified.

Cape Cod Bay and Zooplankton Analysis:

Locating the areas of high zooplankton density based on environmental conditions and physical oceanography was a topic of much discussion. Due to the intensity of RW research in the CCB area, there is a great deal of data that could be analyzed to determine where these patches are most likely found, though it was agreed that the translation to ME habitat may be difficult. CTD data, zooplankton counts and bottom layer characteristics should be analyzed and then cross-referenced with geophysically similar bottom-types in ME waters, to see if there is new information to gained about this relationship.

Zooplankton Monitoring:

Right Whale behavior is dictated by finding sources of food. There is very little information available about the potential food sources for RW in the nearshore waters of the GoM. A zooplankton monitoring program could provide useful information, but would require at least two years of data collection to be meaningful. Three potential research proposals were made:

- Zooplankton pump sampling when whales are sighted;
- Regular zooplankton monitoring through pump and net sampling at MDR, in the Penobscot Current, and Jeffreys Ledge region; and
- Designing a seasonal coastal survey to find the thin layers of zooplankton.

Summary

Current zooplankton and RW research in known locations of risk (Mount Desert Rock and Jeffreys Ledge areas) could be readily expanded to include some of the recommended research strategies in order to relatively quickly determine whether and how RW use those areas for foraging. Research recommendations were prioritized by the panelists, including intensive aerial surveys to search for RW; if whales are found, those areas could be sampled for zooplankton and mapped for physical processes and those parameters could then be projected on similar habitats to determine likely RW feeding areas.

It was agreed that a mix of sampling schemes should be used. Below is a summary of the research strategies suggested or discussed:

Zooplankton --

- Small-scale studies on coast of Maine may be the way to go.
- A hierarchical study plan of zooplankton patch aggregation is needed which would include modeling and sampling.
- A.Pershing and colleagues have suggested a model based on background zooplankton concentration changes.
- Mechanisms of patch formation need to be investigated further. Catching these patches in action has proven difficult and examining physical mechanisms may be a good strategy.
- The extensive shelf edge of the western GoM has not been sampled very much. As this is all part of the environment of RWs, an exploratory effort should be made in these areas.
- Investigating the intersection of offshore banks with deeper water (80, 100, 120 m?) might be reasonably promising.
- Operational aspects of GoMOOS buoys make a broad-scale sampling and modeling effort reasonable.
- Fine scale oceanographic features need to be explored to determine zooplankton distribution.
- Modeling exercises may be helpful in identifying areas that are likely locations for *Calanus* patches. Tracking environmental conditions that spawn zooplankton patches might be helpful.
- Look at other fish species to locate *Calanus* (i.e. herring).
- Identify the occurrence of fixed fishing gear in areas of high-density zooplankton. There should be a concentrated study around areas of high risk for whale entanglements.
- Focus on the relationship between the local fluid conditions and where different species aggregate relative to these features. It may be fruitful to pare down our efforts and begin studying the behavior of animals at the scale of the individual.
- Consider the relationship between algal blooms and zooplankton and research what feeds the copepods.
- Find an aggregation of plankton, then sample that area to find features that impact the resource.
- Perform oceanographic sampling where the RW show up by looking at turbulence near rocky bottom and do particulate sampling even if whales aren't there.

- Review GoM current and tide profiles and layer this information with depth.
- MDR and Jeffreys Ledge should be explored further to find out where the prey are located to determine management and gear adjustments.
- Get focused looks at bottom stress to then extrapolate.
- Conduct a nearshore plankton-sampling program.
- Shifts between *Calanus* and other zooplankton and the results for RW are important for understanding trends in RW populations.

Right Whales –

- More studies are needed in whale energetics, but need an efficient way to study/test.
- Transfer COA's extensive sightings data from logbooks to a database.
- Map spatial distribution of fishing gear.
- Upgrade the Maine RW Sightings map so it reflects effort and better represents RW distribution.
- Encourage permitted scientists to place TDR tags on as many RW as possible.

Appendices

1. **Workshop Agenda**
2. **Maine DMR RW Sightings and DAM Map**
3. **Workshop Power Point Presentations**
4. **Limited References**

Right Whale Foraging in the Nearshore Waters of the Northern Gulf of Maine

Friday, April 15, 2005
Saco, Maine

Workshop Agenda

Goal:

Current federal regulations for mitigating fishing gear interactions with North Atlantic right whales (RW) are based on right whale ecology and foraging data procured primarily in near-shore and sandy habitats in the southern Gulf of Maine (south of 43 degrees). Previous workshops have identified the need to obtain better data on RW foraging ecology to more effectively inform management decisions. For example, little is known about the foraging habits of RW on the rocky substrates and areas of strong tide along the coast of Maine. This workshop is being held to identify information gaps and develop a research agenda to identify areas of potential risk for whale-gear interactions along the northern near-shore waters of the Gulf of Maine, and to inform the management process in development of alternative gear and fishing strategies in Maine based on best-available data.

Outcomes of the workshop:

1) To document
   - What is known about right whale foraging habits in northern near-shore waters of the Gulf of Maine; and
   - What is known about the zooplankton used as a food source in this area and how that is influenced by oceanographic conditions.

2) To develop a research agenda aimed at gathering data about how, when and where right whales and zooplankton interact within the northern near-shore waters of the Gulf of Maine.

8:30 **Welcome and Introductions:** Laura Ludwig, Maine Dept. of Marine Resources

9:00 – 10:30 **Right Whale Ecology Panel:** Scott Kraus, New England Aquarium; Moe Brown, New England Aquarium; Mark Baumgartner, Woods Hole Oceanographic Institution; Stormy Mayo, Center for Coastal Studies; Sean Todd, College of the Atlantic – Scott will frame discussion about what is known regarding right whale ecology in the northern near-shore waters of the Gulf of Maine (20-30 minutes). Other panelists will provide additional information and relevant data (10-15 minutes).

Break

11:00 – 12:00 **Framing the Important Biological and Physical Oceanography Questions**: Lew Incze, University of Southern Maine and David Mountain, Northeast Fisheries Science Center -- Lew will lead the discussion about what is known regarding oceanography in the Gulf of Maine relevant to northern near-shore areas and sampling techniques (20-30 minutes) with David providing other information and relevant data.

Lunch

1:00 – 2:30 **Zooplankton/*Calanus* Panel:** Stormy Mayo, Center for Coastal Studies; Ted Durbin, University of Rhode Island; Jeff Runge, University of New Hampshire; David Fields, Bigelow Laboratory -- Stormy will provide the background and frame the discussion about what we know about *Calanus* (or euphausiids etc.) as a food source for right whales in northern near-shore areas of the Gulf of Maine. Stormy will address likely techniques and prospects for sampling along the Maine coast. Ted, Jeff and David will provide other information and relevant data or sampling techniques.

2:30 – 3:00 **Mapping Exercise**
Charts will be provided to physically map where we know right whales occur, where *Calanus* (or other important forage) is found, and where fishing occurs, and begin to identify gaps in knowledge (i.e. what areas do we have little knowledge about? During what seasons?) and where there is potential known overlap of whales, forage and fishing.

3:00 – 4:30 **Discussion Questions:**

- What is the transit course of RW through the northern GOM?
- Is there a food source for Right Whales while traveling along coastal Maine? If so, what is it? And what habitat is required for this food source?
- How can existing data and/or techniques be used to get the information we need?
- What new research questions should be pursued to better address these questions and better inform management decisions?

4:30 **Prioritize Research Questions and Define Next Steps**

5:00 **Adjourn**

Limited References

Baumgartner, M.F. and Mate, B.R. 2005. Summer and fall habitat of North Atlantic right whales (*Eubalaena glacialis*) inferred from satellite telemetry. *Canadian Journal of Fisheries and Aquatic Sciences* 62:527-543.

Baumgartner, M.F. and Mate, B.R. 2003. Summertime foraging ecology of North Atlantic right whales. *Marine Ecology Progress Series* 264:123-135.

Baumgartner, M.F., Cole, T.V.N., Clapham, P.J. and Mate, B.R. 2003a. North Atlantic right whale habitat in the lower Bay of Fundy and on the SW Scotian Shelf during 1999-2001. *Marine Ecology Progress Series* 264:137-154.

Baumgartner, M.F., Cole, T.V.N., Campbell, R.G., Teegarden, G.J. and Durbin, E.G. 2003b. Associations between North Atlantic right whales and their prey, *Calanus finmarchicus*, over diel and tidal time scales. *Marine Ecology Progress Series* 264:155-166.

Clapham, P.J., ed. 2004. Improving right whale management and conservation through ecological research, Report of the working group meeting on April 16, 2004, Woods Hole MA. 12 pp.

Clapham, P.J., ed. 1998. Predicting right whale distribution, Report of the workshop held on October 1-2, 1998, Woods Hole MA. 53 pp.

Goodyear, J.D. 1996 Significance of feeding habitats of North Atlantic right whales based on studies of diel behaviour, diving, food ingestion rates and prey. Ph.D. dissertation. University of Guelph. 269 pp.

Mayo, C.A., Nichols, O.C., Bessinger, M.K., Marx, M.K., Browning, C.L. and Brown, M.W. 2004. Surveillance, monitoring and management of North Atlantic right whales in Cape Cod Bay and adjacent waters – 2004. Final Report. 126 pp.

Murison, L.D. and Gaskin, D.E. 1989. The distribution of right whales and zooplankton in the Bay of Fundy, Canada. *Canadian Journal of Zoology* 67:1411-1420.

Woodley, T.H. and Gaskin, D.E. 1996. Environmental characteristics of North Atlantic right and fin whale habitat in the lower Bay of Fundy, Canada. *Canadian Journal of Zoology* 74:75-84.

Recorded Right Whale Sightings and DAM Areas in the Northern Gulf of Maine

Maine Department of Marine Resources 2005

DRAFT - Not for navigational or enforcement purposes